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THE COLOR CHANGE IN VIVIANITE AND ITS EFFECT ON THE OPTICAL PROPERTIES

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VIVIANITE, the hydrous phosphate of ferrous iron, is generally described as colorless when pure and unaltered, but in most of its known occurrences it is green to blue, the latter color being probably the most common. The streak is at first colorless to faint bluish white, but rapidly changes to deep blue on exposure. Reduction of the mineral to powder by grinding likewise produces a rapid change in color, from colorless to deep blue. This change in color of vivianite has been ascribed to oxidation of a part of the iron to the ferric condition, since analyses of the strongly colored varieties of the mineral invariably show the presence of ferric oxide in quantity ranging up to 33 per cent. or more.

In a recent study¹ of vivianite in large crystals from a new locality near Plant City, Florida, it was found on microscopic examination that fragments broken from the pale green crystals, or coarse powder, immediately after grinding, were colorless and non-pleochroic. The powder, however, rapidly changed to deep blue and became strongly pleochroic. The microscopic aspect of the material suggested that the change might possibly be due to inversion from one form to another, and not to oxidation.

Chemical study of the mineral was undertaken to determine the cause of this change in color, which was observed to progress most rapidly on exposure, especially in sunlight. A lot of uniformly colored pale green crystals was selected and divided into two portions (a) and (b) in each of which ferrous iron was determined; (a) without grinding, and (b) after fine grinding. The

¹ Watson, T. L. and Gooch, S. D.: *Jour. Wash. Acad. Sci.*, 8, (4), 82-88. 1918; see abstract in this number, p. 168.

unground sample of vivianite crystals gave on analysis 42.88 per cent. FeO and no Fe_2O_3 , as against 38.43 per cent. FeO in the finely ground sample. The figures clearly show that fine grinding resulted in the oxidation of 4.45 per cent. FeO to Fe_2O_3 , equivalent to 4.94 per cent. Fe_2O_3 . The results prove beyond reasonable doubt that the change of color in vivianite is due to oxidation and not to inversion. The rapidity with which oxidation takes place on fine grinding is noteworthy.

This rapid change of color in vivianite being thus shown to be due to oxidation and not to inversion, attention was directed to the effect of oxidation of a part of the ferrous iron upon the optical properties of the mineral. A search of the literature was without results, since the optical data given for the mineral from different localities were not accompanied by chemical analyses; this situation, which is met with in connection with many mineral descriptions, should certainly be remedied in future work.

TABLE 1. OPTICAL DATA FOR VIVIANITE

	Color.	Authority.	Char-acter.	Refractive Indices.				Pleochro-ism.
				α	β	γ	2V	
1	Pale green	Larsen ²	+	1.580	1.598	1.627	large	None
2	Deep blue	Larsen ³	+	1.579	1.603	1.633	85°	Strong
3	Blue	Rosicky ⁴	+	1.5809	1.6038	1.6361	73° 7-20'	Weak
4	Blue	Winchell ⁵	-	1.5766	1.6050	1.6267	73° 10'	Strong

² 1.5 miles southeast of Plant City, Florida. Watson and Gooch, *loc. cit.*

³ Mullica Hill, New Jersey. The writer is indebted to Dr. Larsen for permission to include these hitherto unpublished results.

⁴ Valdic, Bohemia. Quoted by Ford, *App. III, Dana's System of Mineralogy*.

⁵ *Optical Mineralogy*, p. 388, 1909.

The optical data determined by Dr. Larsen, for the Florida material, as given in the paper above cited, were obtained on pale green fragments, and undoubtedly represent true, unaltered, vivianite. The data given in the literature, on the other hand, appear to have been measured in most cases on blue material, in which part of the ferrous iron had been oxidized to the ferric state. The discrepancies between the various statements are probably explainable in this way, altho in the absence of analyses the exact relation of change in refractive indices and other properties to the ferric iron content can not be traced.

Nevertheless it may be of interest to compare the data on specimens from different localities; this is done in table 1.

The pleochroism of finely ground material from occurrence 1 is essentially identical with that shown by 2 and 4, namely: X deep blue, Y nearly colorless, Z colorless, pale olive green, or brownish. As in the first case the amount of ferric oxide is known to have increased from practically zero to nearly 5 per cent. it seems reasonable to conclude that the pleochroism is connected with this change in all cases, and that pure vivianite is an essentially non-pleochroic mineral.

With reference to the other optical properties, allowing for such variation as is likely to be shown from one specimen to another, coming from widely separated localities, and studied by different investigators, it seems clear that the oxidation of part of the iron is connected with a definite increase in the values of refractive indices β and γ , while α remains constant within the limits of accuracy of measurement. The relations in the case of the optic axial angles are less clear, for the data given appear to be inconsistent. Calculation of the angles for numbers 3 and 4 of table 1 by the usual formulas⁶ gave $82^{\circ}7'$ and $81^{\circ}46'$ respectively, whereas the values observed are decidedly less than these.

The general conclusions are justified, however, that the change of color shown by vivianite on exposure or grinding is connected with partial oxidation of the iron to the ferric condition, and that marked changes in pleochroism and refractive indices are connected with this alteration.

NOTE ON IRON AS A CAUSE OF BLUE COLORS IN MINERALS.

EDGAR T. WHERRY. *Washington, D. C.*—Since ferrous iron usually colors minerals green, and ferric iron yellow or brown, it may seem rather remarkable that the presence of both together should give rise to a blue color, as in the case described in the above paper. It may be pointed out, however, that this is by no means a unique instance of such an effect. Even apart from the artificial substances, "Prussian" and "Turnbull's" blues, which are complex cyanides containing both ferric and ferrous iron, there are several blue minerals in which the color seems explainable only on this basis. The most noteworthy of these are: crocidolite and related amphiboles; iolite; and blue tourmaline or indicolite. Other instances may perhaps be discovered, should this subject ever be investigated as it deserves to be.

⁶ See Johannsen, *Manual of petrographic methods*, p. 103, 1914.

COPIAPITE IN COAL

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MELANTERITE is of rather frequent occurrence in old entries of bituminous coal mines, forming bunches of silky fibers, and masses weighing as much as 30 pounds have been reported. A specimen of this mineral was obtained for our museum in an abandoned working of the Congo coal mine in Perry County, Ohio. The sample, as received, was a beautiful light green fibrous mineral resembling fibrous serpentine. The melanterite was contained between slate partings in the coal, its fibers being about two centimeters in length.

The specimen, after examination and cataloging, was put in a cardboard box and deposited in the museum. On examination about a year later the mineral was found to be dotted over with yellow particles, which seemed to represent an alteration product of the melanterite. The latter had in the meantime changed from a pale green color to a dull white, and its fibers had become brittle. The yellow particles were certainly not on the specimen as received from the mine, and seemed to have formed chiefly at the contact points of the melanterite and the shale.

Under the microscope the yellow lumps were found to be groups of plates 0.05 mm. by 0.03 mm. in size. The plates showed a crystal outline with somewhat rounded edges and corners. When standing on edge they showed parallel extinction and a positive elongation.

An obtuse bisectrix ($Bx_0 = a$) emerged normal to the tabular face. The acute bisectrix ($Bx_a = c$) made an angle of -53° with the principal direction of elongation (d).

The indices obtained were: $\alpha = 1.525$; $\beta = 1.545$; $\gamma = 1.595$ all ± 0.003 ; sign therefore $+$. Pleochroism was very marked with a and b colorless and c deep yellow. These results appeared to indicate the mineral to be copiapite altho the data differ somewhat from those recorded in the literature.¹

Enough of the yellow mineral had formed in something over a year to give enough material for an accurate chemical analysis,

¹ The optical properties of different samples of copiapite vary rather widely, altho it seems to be uniformly $+$ rather than $-$ as usually described, and the means of my measurements lie close to the values given by Dr. McCaughey. The cause of this variation should be further investigated.—E. S. LARSEN.

which yielded: Insoluble 0.31, Fe_2O_3 29.98, SO_3 39.68, H_2O 30.45, sum 100.42 per cent. The water was determined by mixing the sample with anhydrous PbCrO_4 and igniting the mixture in a combustion furnace, catching the water in a weighed CaCl_2 tube. The formula indicated is $\text{Fe}_2\text{O}_3 \cdot 5\text{SO}_3 \cdot 18\text{H}_2\text{O}$.

The microscopic examination and the chemical analysis show that the mineral is undoubtedly copiapite. Such a transformation from melanterite to copiapite is worthy of note, especially as it took place in the dry atmosphere of a mineral cabinet, while the mineral specimen was enclosed in cardboard.

Because of these rather unexpected results, it was thought worth while to examine a coal reported to contain sulfur. It was found on examination that the label was in fact wrong, and the "sulfur" proved to be *copiapite*. It is more than likely that many if not all of the reported occurrences of elementary sulfur in coal and in slack piles are due to the presence of this mineral. The color is strikingly similar to sulfur, and the mineral has somewhat the appearance of the sulfur found in some of the hot springs of Yellowstone Park.

PROCEEDINGS OF SOCIETIES

THE PHILADELPHIA MINERALOGICAL SOCIETY

WAGNER FREE INSTITUTE OF SCIENCE, MAY 9, 1918

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Dr. Leffmann, in the chair. Twelve members and two visitors were present.

Mr. John G. Rothermel addressed the society on the Geology and Mineralogy of the Petrified Forest of Arizona, illustrated with lantern slides and specimens. Dr. Leffmann exhibited some radiographs.

Mr. Gordon reported the following trips.

(1) Devil's Pool, Wissahickon Creek. About 200 feet north of the pool is an exposure of a meta-pyroxenite dike (a mixture of talc and amphibole) which has metamorphosed the Wissahickon "gneiss" (mica schist) immediately adjoining with the development of cyanite and staurolite. The cyanite is obtainable in indifferent specimens. The staurolite is found in abundance, weathered out of the schist, on top of the hill, in crystals, sometimes twinned, up to two inches in length.

(2) Deshong's quarry, Leiperville, Delaware County. Large microcline crystals were obtained and one large yellowish green beryl, 14 inches long and $1\frac{1}{2}$ inches thick, somewhat altered on the surface and opaque, but clear and exhibiting a good aquamarine color where broken across.

(3) Gottschall's mine, 1 mile northwest of Capella Hill, Alsace township, Berks County. Nickeliferous pyrrhotite and augite are abundant.

(4) Valentine Hartmann's mine on Antietam Creek, 1 mile west of Spies Church, Alsace township, Berks county. Only inferior specimens are now obtainable at this famous old molybdenite locality.

(5) Ocher pit, $3\frac{1}{2}$ miles southwest of Pricetown, Alsace Township, Berks County. Fine limonite, stalactitic and mammillary, obtainable in geodes up to two feet long.

(6) Udree's mine, an old limonite bank, 1 mile south of Pricetown, Ruscombmanor Township, Berks County; this is surrounded by extensive, but practically barren dumps. Specimens of psilomelane and turgite were found.

(7) Quarries at Trap Rock, 2 miles south of Birdsboro, Berks County. Calcite in brilliant, but small, yellow rhombohedral crystals; groups of small clear stilbite crystals, laumontite and prehnite.

(8) Small abandoned trap quarry $\frac{1}{2}$ mile south of St. Peters Station, W. & N. R. R., Knauertown, Chester county. The Triassic diabase here overlies a quartzite, and small veins of andradite and specular hematite occur in the latter near the contact.

(9) Hopewell mines, Steel's mine on Steel's Hill, and St. Mary's mines at Warwick, Warwick township, Chester county, formerly well-known localities. These mines have not been worked for years, and nothing of interest is obtainable.

(10) French Creek mines. The upper mine, formerly known as the Elizabeth mine, is now in active operation, but little of interest was obtained. However, there is a possibility of it becoming a good locality again. The Keim mine, or lower mine, lies 200 feet southwest of the upper mine, and there is hope also of this mine being reopened. A fine calcite crystal was secured—a combination of the forms m (10 $\bar{1}$ 0), v (21 $\bar{3}$ 1) and e (01 $\bar{1}$ 2) (striated), the unit prism, scalenohedron and rhombohedron respectively. This crystal is from a group of colorless crystals, the largest measuring 2 inches long by $\frac{1}{2}$ inch thick, obtained at the Keim mine when it was being worked.

(11) Jones mine, $\frac{3}{4}$ mile east of Joanna, Berks County. This long abandoned magnetite mine is now an immense reservoir of water surrounded by extensive dumps. Malachite, azurite, and fine crystals of pyrite, chalcopyrite, magnetite (dodecahedral) and aragonite were obtained.

Mr. Trudell reported the society's trip to Brinton's quarry, where jefferisite (one crystal 9 inches long), clinocllore, magnesite, deweylite and asbestos were found.

Mr. Gordon exhibited a fine andradite crystal from Cornwall, Lebanon County. The crystal is brown olive, measuring one inch in diameter. The form is a trapezohedron (tetragonal trisoctahedron), n (211), striated parallel to the shorter diameter or the edges of minute dodecahedral faces; the striations are probably due to an oscillation between these two forms. The crystal is studded with occasional minute pyrite and smaller andradite crystals.

SAMUEL G. GORDON, *Secretary*.

THE NEW YORK MINERALOGICAL CLUB.

The final regular meeting of the New York Mineralogical Club for the season of 1917-1918 was held on Wednesday, May 8th, 1918, in the Audi-

torium of the Museum of the Brooklyn Institute of Arts and Sciences, Eastern Parkway and Washington Ave., Borough of Brooklyn, New York City. The President, Dr. George Frederick Kunz, was in the Chair.

The announced program presented was "an exhibit by the Secretary of 150 lantern slide photographs of various mineral localities of New York City and vicinity, past and present, and some of the minerals they have produced." These photographs were chiefly made by or for the speaker from time to time since 1867, but included a few of special interest contributed by others.

The views of localities illustrated, some the gradual working out of veins, and others groups of Club members on various excursions. The exhibit included many selected to show the comparative results afforded by various photographic methods, and many kinds of plates, such as the old time collodion wet plate, the Monroe, Carbutt, Cramer, Stanley, and Seed plain dry plates (some hand colored), the Seed G.B.P.R. color plates, and the Joula and Dufay Autochrome or natural color plates. Cabinet specimens shown in the views were mounted on blocks with attached labels, each of standard size and the specimens shown in the photomicrographs were mounted in standard Rakestraws. The illustrations were thus designed to be of interest from diverse points of view.

Upon conclusion of the lecture a vote of thanks was tendered to the speaker, and after a brief "conversazione" the meeting adjourned.

WALLACE GOOLD LEVISON, *Secretary*.

NEW MINERALS

COLERAINITE

Eugene Poitevin and R. P. D. Graham: Contributions to the mineralogy of Black Lake Area, Quebec. *Canada Dept. Mines, Museum Bull.* 27, 66-73, 1918.

NAME: from the locality, Coleraine township, Quebec.

PHYSICAL PROPERTIES

Color: colorless to white, faint pink and pale brown. Luster: vitreous, dull or pearly. Form: thin hexagonal plates or flakes (1 mm. in diameter), often aggregated into rosettes or spheres; also fine granular and compact. Sp. Gr. = 2.51. H. = 2.5 - 3.

OPTICAL PROPERTIES

Under the microscope the crystal flakes are isotropic; uniaxial, the optic axis emerging normal to the flakes; birefringence + and weak, with mean refractive index about 1.56.

CHEMICAL PROPERTIES

Composition: $H_2Mg_2AlSiO_8$, a hydrated magnesium aluminium silicate, near newtonite. An analysis of crystals by M. F. Conner gave: SiO_2 24.40, Al_2O_3 22.77; Fe_2O_3 0.45, MgO 32.70, CaO 0.10, $(Na,K)_2O$ 0.30, MnO 0.09, H_2O 19.63, sum 100.44 per cent.

B. B. whitens, disintegrates, finally fusing to a white glass which moistened and heated with cobalt nitrate becomes blue. In the closed tube whitens and decrepitates. Decomposed with difficulty by HCl with the separation of flocculent silica.

OCCURRENCE

Colerainite occurs in veins believed to be of pegmatitic origin in serpentine. Found at the old Standard mine and on the dumps of the Union Pit, Coleraine Township, Megantic County, Quebec. S. G. G.

ABSTRACTS OF MINERALOGIC LITERATURE

CONTRIBUTIONS TO THE MINERALOGY OF BLACK LAKE AREA, QUEBEC. EUGENE POITEVIN and R. P. D. GRAHAM; *Canada Dept. Mines, Museum Bull.* **27**, 82 pp., 12 pl., 22 figs.; 1918.

This bulletin is descriptive of the minerals of the Black Lake Area, in the "serpentine belt," Megantic township, Quebec. The rocks of the belt are predominantly basic,—gabbro, diabase breccia, pyroxenite, peridotite, and serpentine,—but include granite and aplite; all are believed to have originated by progressive differentiation from a single parent magma.

A peculiar occurrence is that of calcium silicates, diopside, vesuvianite and grossularite in compact granular dikes in peridotite or serpentine. It is suggested that these dikes were deposited by hydrothermal solutions as the last stage of the intrusion, deriving much of the lime from the walls of the fissure thru which the solutions passed.

Thirty-four minerals are described, including diamond, chromite, quartz, calcite, aragonite, stichtite, diopside, grossularite, vesuvianite, clinocllore, serpentine, apatite, and one new mineral, colerainite (described under that heading above).

Microscopic diamonds occur in chromite, the crystals exhibiting parallel growth of the octahedron.

The following doubtful forms were observed on quartz: (13.6.19.6), (9.5.14.5), (13.9.22.9), (6.5.11.5), the last fairly well defined.

The rare mineral stichtite, previously found only in Tasmania, was noted at the old Megantic mine, occurring as small lilac-colored patches or narrow veinlets in serpentine.

Diopside occurs in several varieties, one remarkable absolutely colorless and transparent, in pseudoprismatic crystals due to the unique development of the acute hemi-pyramid λ (331). Thirty-nine forms were observed, including the new ones: χ_1 (610), D_1 (13.0.4), J_1 (902), I_1 (701), Y_1 (423), r (15.4-10), s (534), x_1 (773), δ_1 (8.11.4), N_1 (191), O_1 (10.13.3); and the rare forms: g (210), \mathfrak{F} (140), F (301), I (702), M (401), Ψ (501), n (102), ρ (332), W (441), L (131), ϵ (121), and λ_1 (552). An analysis gave: SiO_2 54.77, Fe_2O_3 0.17, FeO 0.89, MnO 0.11, MgO 18.46, CaO 26.33, sum 100.73 %. The refractive indices were determined by total reflection: $\alpha = 1.669$, $\beta = 1.676$, $\gamma = 1.698$.

Grossularite occurs, exhibiting the following forms: a (100), δ (610), e (210), g (320), r (332), m (311), n (211), and s (321); an analysis is given.

Vesuvianite occurs in a variety of colors and fairly rich in forms, including the rare ones v (151), and r (461). An average of 10 fairly good determinations of n by total reflection gave $\omega = 1.768$, $\epsilon = 1.705$, $\omega - \epsilon = 0.003$. Several analyses are given. S. G. G.

WEATHERING OF ALLANITE. THOMAS L. WATSON. Univ. of Virginia. *Bull. Geol. Soc. Amer.*, **28**, 463-500, 1917.

The distribution of allanite in the eastern United States is described, with data as to occurrence and composition. The ordinary black vitreous allanite is apparently not homogeneous, but is made up of at least two types which vary in proportion: one is isotropic, the other birefracting, and probably derived from the former by alteration.

When found at or near the surface, the allanite masses are usually partially or entirely encrusted with a reddish-brown alteration product, composed of a variable mixture of colloidal or metacolloidal isotropic and weakly birefracting grains. Chemical analyses disclose the variable nature of the altered product, composed chiefly of water, ferric oxide, alumina, ceria and silica. S. G. G.

THE RADIOACTIVITY OF ALLANITE. L. S. PRATT. Univ. of Virginia. *Trans. Am. Inst. Min. Eng.*, **60**, 935, 1917.

The radioactivity of allanite from Topsham, Maine, was measured with an electroscope. S. G. G.

NOTES ON THE TECHNIQUE OF MINERAGRAPHY. W. L. WHITEHEAD, *Econ. Geol.*, **12**, (8), 697-716, 1917.

The preparation of polished sections of sulfides presents difficulties due to variations in hardness, pronounced cleavage, etc., causing the formation of pits, cracks, and high relief, which obscure the contact relations. Accordingly elaborate methods have been developed for grinding and polishing sections, which are described in great detail, with further notes on microscopic and photomicrographic procedure. A method for the identification of the silver sulfides by "light etching," and a table of microchemical tests is also given. S. G. G.

MINASRAGRITE, A HYDROUS SULFATE OF VANADIUM. WAL-DEMAR T. SCHALLER. U. S. Geol. Survey. *J. Wash. Acad. Sci.*, **7**, (16), 501-503, 1917.

This mineral was first noted in "Four new minerals," described in *J. Wash. Acad. Sci.*, **5**, (1), 7, 1915; and later (W. T. S., priv. contr.) in the *Third Appendix to Dana's System of Mineralogy*, p. 51, 1915. The present paper presents an analysis of the mineral. From examination of cleavage fragments it is concluded that it is monoclinic or triclinic. S. G. G.

A NEW METEORITE. HENRY L. WARD. Public Museum of Milwaukee. *Science*, **46**, (1185), 262, 1917.

Note of fall of an achondritic aerolite in Colby, Wis., July 4, 1917, about 6.20 P. M. A brief description is given of the stone. S. G. G.

AN EGYPTIAN METEORITE. HENRY WILDE. *Manchester Lit. Phil. Soc. Memoir* **4**, 1917, 2 pp.

Note on a stone weighing 3.5 lbs. that fell near the encampment of a British regiment on the Sinai Peninsula, in August, 1916. S. G. G.

ON THE PHOTOGRAPHIC SPECTRA OF METEORITES. SIR WILLIAM CROOKES. *Phil. Trans. Roy. Soc. London*, **217** (A, 559) 441-450, 1917.

The spectroscope used is described in detail. The arc spectra of 30 aerolites were examined. S. G. G.

LOW-TEMPERATURE FORMATION OF ALKALINE FELDSPARS IN LIMESTONES. REGINALD A. DALY, Harvard University. *Proc. Nat. Acad. Sci.*, **3**, (11), 659-665, 1917.

The author reviews the work of ten writers describing the occurrence of orthoclase and albite in automorphic crystals in non-metamorphosed limestones, describing another similar occurrence in the Rocky Mt. dolomite at Waterton Lake, with analyses. It is believed that the minerals crystallized at low temperatures in the calcareous muds. S. G. G.

THE FORMATION OF CRYSTALS IN GELS. HARRY N. HOLMES, Oberlin College. *J. Frank. Inst.*, **184**, (6), 743-773, 1917; *J. Phys. Chem.*, **21**, (9), 709-733, 1917.

A number of experiments were made in growing crystals of metallic salts in gels (principally silicic acid gel), by diffusion. Good crystals, sometimes of large size, were obtained. S. G. G.

FAMATINITE FROM GOLDFIELD, NEVADA. EARL V. SHANNON *Am. J. Sci.* [4], **44**, (12), 469-470, 1917.

Famatinite is shown to be isomorphous with enargite; prism angles:

	Observed, Famatinite	Enargite (Dana)
$x : x'''$	60° 24'	60° 17'
$h : h$	59° 12'	59° 43'

The domes observed, (104) and (025), gave too poor reflections for the calculation of the c axis. S. G. G.

THE MINERALS OF THE MEEKATHARRA DISTRICT (WESTERN AUSTRALIA). E. S. SIMPSON. Western Australia Geol. Survey. *Bull.* **68** 288-307, 1917.

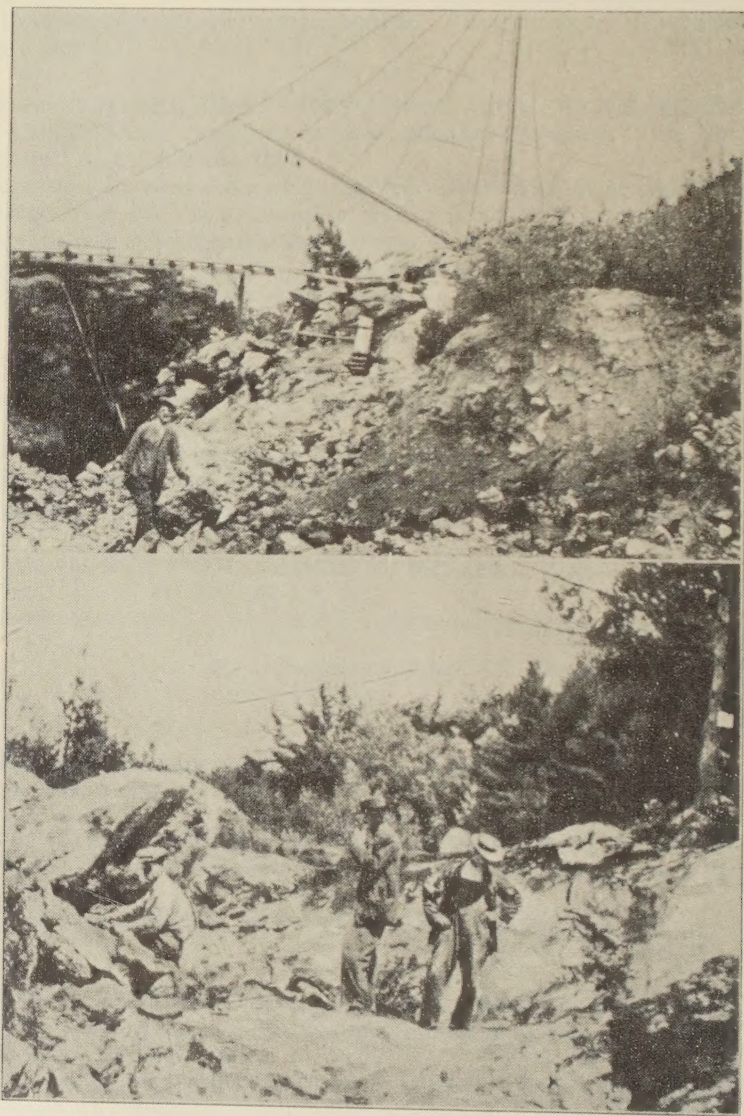
An annotated list of the minerals of the district and their paragenesis.

S. G. G.

VIVIANITE FROM THE LAND PEBBLE PHOSPHATE DEPOSITS OF FLORIDA. THOMAS L. WATSON and STAPLETON D. GOOCH. *J. Wash. Acad. Sci.*, **8**, (4), 82-88, 1918.

Vivianite occurs distributed irregularly as single crystals and crystalline aggregates in a ferruginous or dark yellow ochereous earth, about $1\frac{1}{2}$ m. south-east of Plant City, Fla. A description of the physical and optical properties of the material is given, with an analysis. The color of the mineral varies from light green to indigo blue. The latter color is also derived from the former by exposure to light, and is caused by oxidation, induced by fine grinding of the mineral. The vivianite is of secondary origin, formed, it is believed, by the action of ferrous iron in solution on the phosphate pebbles. S. G. G.

PLATE 15.



Photos J. G. Manchester.

MAINE MINERAL LOCALITIES.

1. Gem Tourmaline Mine, Mt. Mica.
2. Pulsifer Mine, Mt. Apatite.